Ezone TX module Version 1.0 902-928 MHz
ISM Band Transmitter Manual/Specifications

Revision History

Rev	ECO No.	Date	Comments
1.0		11/15/99	Initial FCC submission document

Table of Contents

1.0 Purpose

The purpose of this report is to provide a more detailed description of the connections, usage, schematics, and parts lists. This report is to be used in combination with the EMI TEST REPORT to be submitted to FCC for certification of the Ezone TX module product V1.0 900MHz ISM band Transmitter.

2.0 Scope

The document although used primarily in combination with the EMI TEST REPORT for FCC certification submission, does contain information included in documents such as the users manual, and test procedures.

3.0 Test Description

3.1 Test Configuration

Unit Name – Processor, Monitor, Printer, Cable, Etc. (indent for features of a unit)	Style/Model/Part No.	Serial Number	Obj. of test	120V	220V	Comments/FCC ID#
Ezone TX module V1.0	ETXMOD9000A	001	✓	✓		

3.2 Equipment Description

This module is to be used in various models of a compact Entertainment System for Fitness Industry. A typical system consists of an audio/video system with self-contained audio CD, audio cassette tape, and television with wireless headphone. The audio channel of one of the three sources is selected and transmitted to wireless headphones using this TX module.

3.2.1 Mode of Operation for FCC EMI Test

The EUT that was used during the testing was connected through an interface cable. This cable provided both the serial communications used to control the EUT and supply audio signals necessary for operation. This cable was connected to a laptop computer located remotely. This laptop computer contained special test software that allowed the transmitter frequency, power output, and modulation to be changed manually. The transmitter power output was adjusted until the radiated level was in compliance with the maximum FCC allowable limit. **It must be emphasized that the power output, and modulation adjustments <u>cannot</u> be adjusted in normal operation of the TX module. These values are only adjusted when calibrating the TX module during manufacture and during the FCC EMI testing setup.**

The location of the Laptop was such that it did not interfere with the emission measurements made at the test site. The laptop and special software used on the laptop would was only used in order to allow modifications of power output and modulation during the tests for compliance. During the manufacturing calibration these settings would be loaded into a non-volatile EEPROM on a manufactured unit (see additional information on manufacturing calibration procedure). These settings would be retrieved from EEPROM during power-up of the TX module during normal operation and used to set the default adjustment pots on the module. The carrier modulation was also calibrated to give a standard peak modulation deviation of 75KHz during normal operating audio input levels (see additional information on manufacturing calibration procedure). The EUT under test used a 1KHz full amplitude audio tone for the reference audio signal.

3.2.2 Mode of Operation for Normal Operation.

The TX module is located within products produced exclusively for E-Zone Networks Inc (E-Zone research and development). This module is not intended to be used or sold separately from intended E-Zone products. All E-Zone products that use this TX module will be verified to be in compliance with FCC allowable limits at a recognized certified test lab. These Verification tests will be performed with the TX module properly installed. The TX module's purpose is to transmit Left and Right channel audio to a 900MHz headphone receiver set. The Left and Right audio signals are fed into the TX module connector. The standard signal levels for these inputs are 2V peak. Any levels in excess of 2V peak are hard limited through the use of input limiting diodes. This prevents any unexpected over-modulation conditions that may occur. The frequency of the carrier is selected using an I2C serial command bus. This bus uses a standard I2C protocol and proprietary command set to select the frequency of the RF carrier signal. Other functions of the TX module can also be changed through this I2C command bus. These functions are:

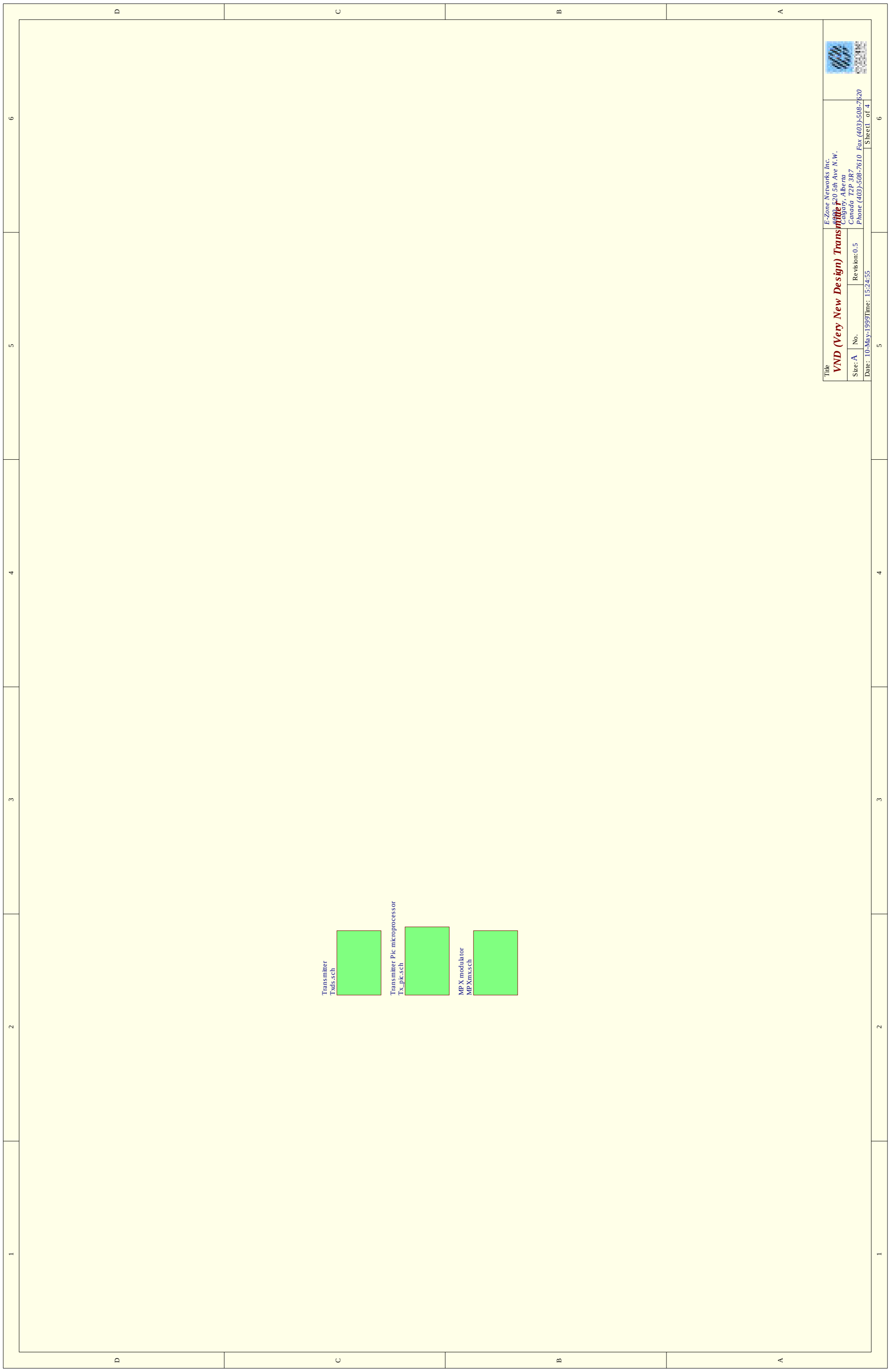
- Carrier On/Off command.
- Pilot tone On/Off.
- TX Power attenuation setting.

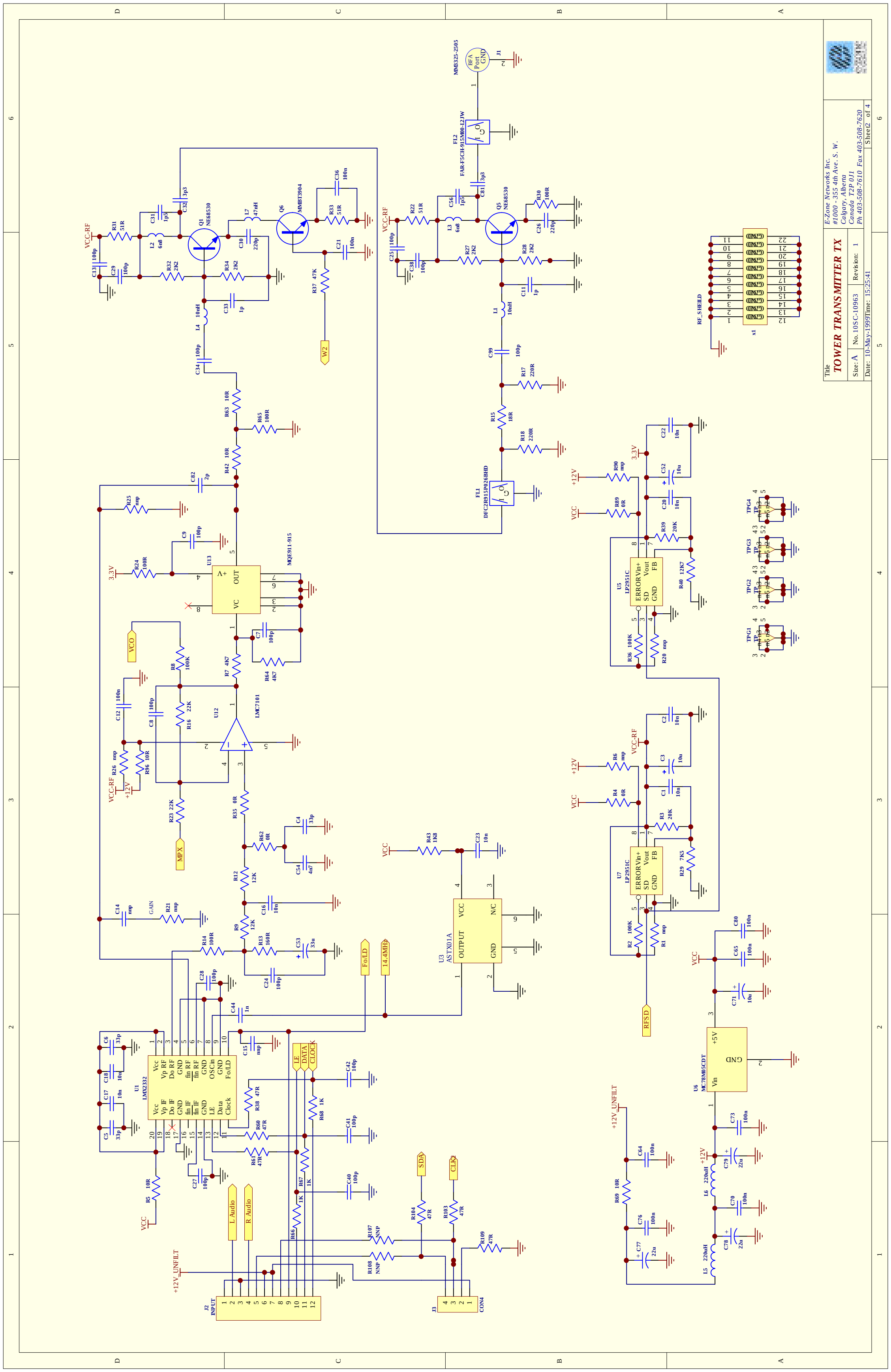
The TX module will accept a DC power supply of 9V to 18V DC. The TX module contains 3 on-board voltage regulators that regulate all circuit sections within the module.

3.3 Antenna Requirement – per 15.203

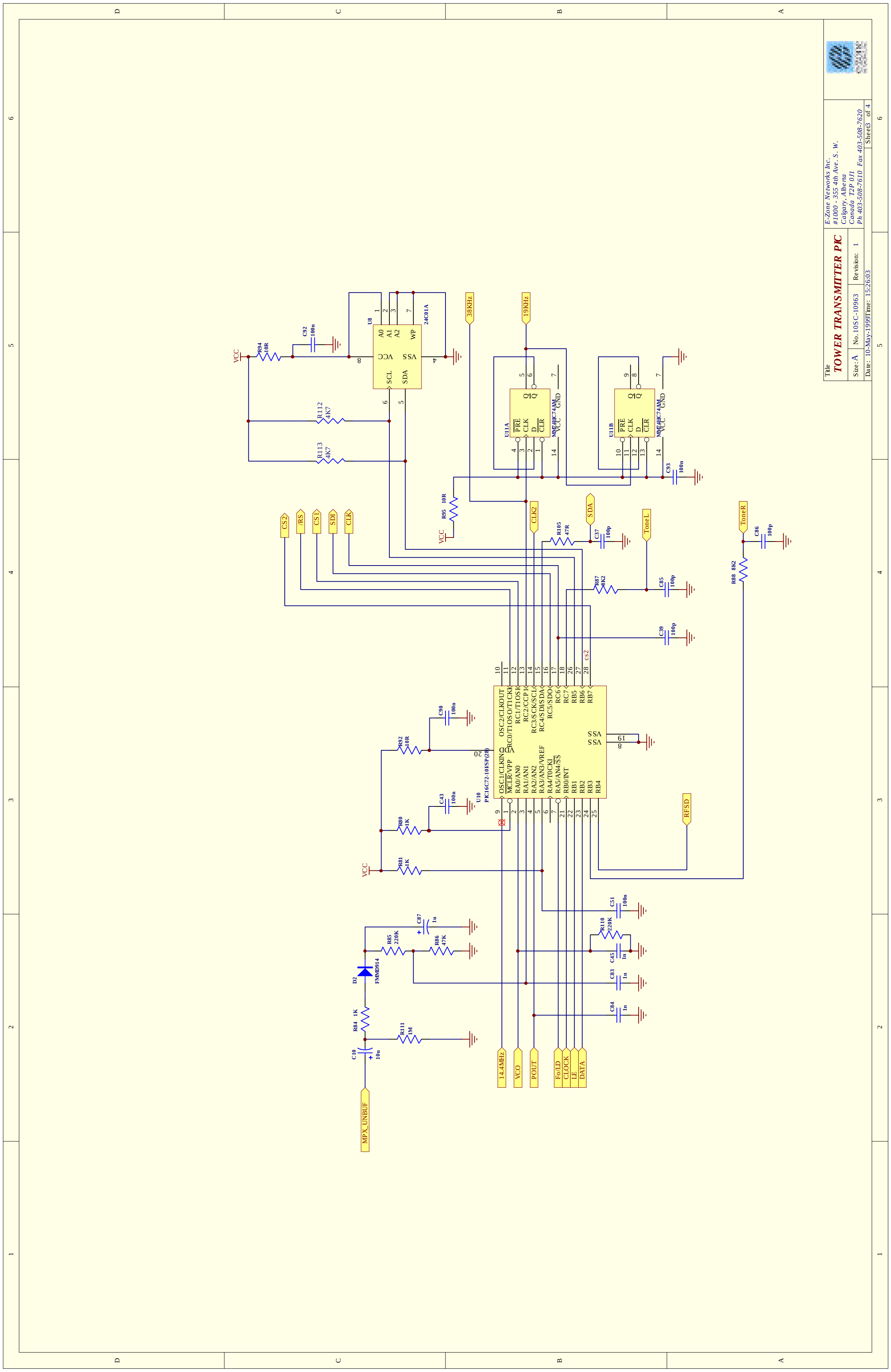
The Antenna is installed during manufacture and cannot be removed or changed by the operator.

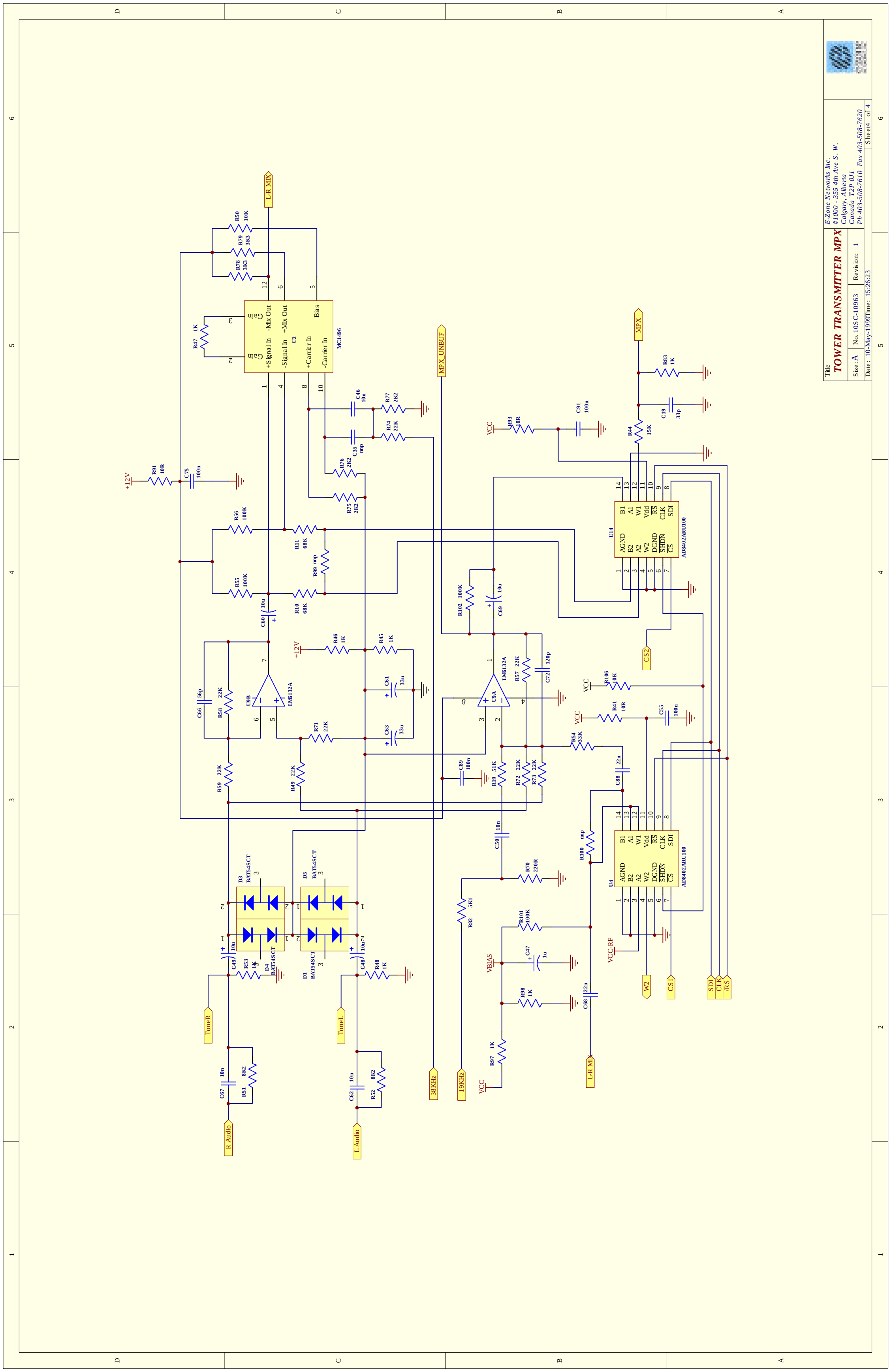
3.4.1 902MHz – 928MHz ISM band Transmitter Module V1.0 Schematics





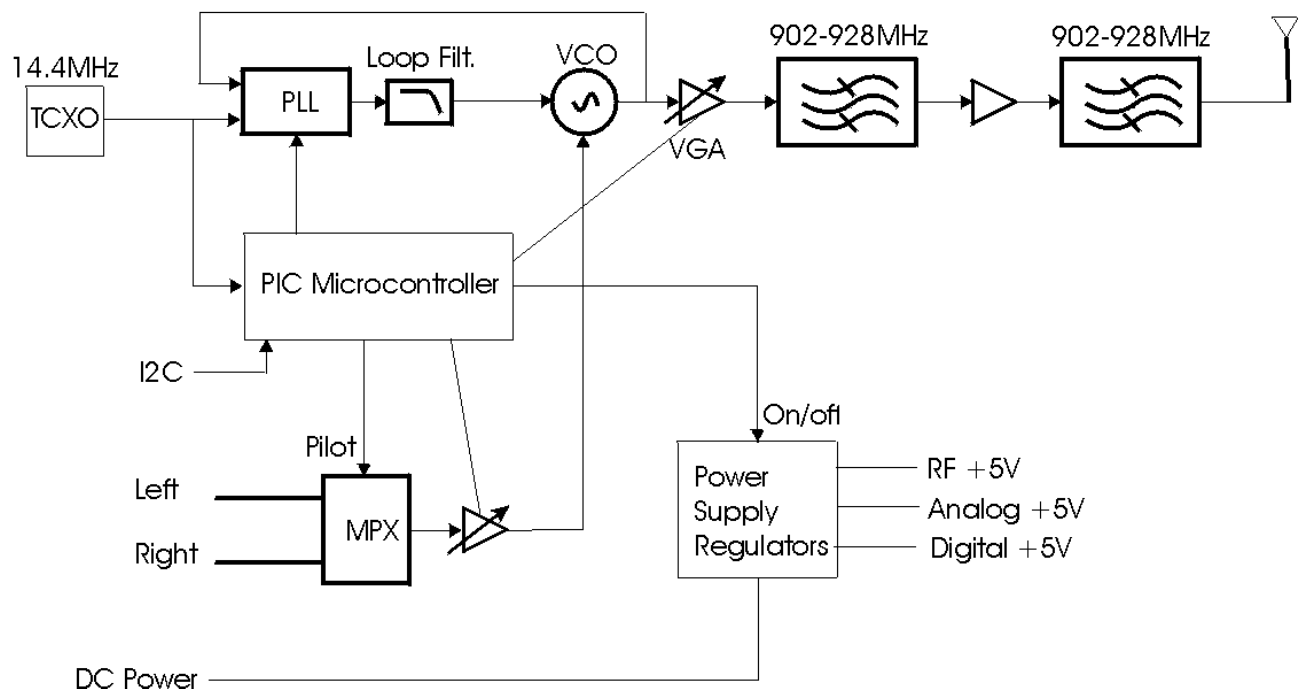
e-zone NETWORKS INC	Calgary Alberta Canada	Title: EZone TX Module V1.0 Manual/Specifications		
		Document No. 308A08-Z	Sheet 7 of 17	Rev. 1.0


TOWER TRANSMITTER PIC
E-Zone Networks Inc.
PIC16C72-10/SP(20)
24C01A
38KHz
19KHz
MPX_UNBUF
14.4MHz
VCO
POUT
RFSD


TOWER TRANSMITTER MPX
MC1496
AD8402ARU100
LM6132A
BAT54SCT
L-R MIX
MPX_UNBUF
MPX
R Audio
L Audio
ToneR
ToneL
38KHz
19KHz
VBIAS
VCC
+12V
SDI
CLK
/RS
CS1
CS2
W2

3.4.2 Circuit Description – per 2.1033(b)4

This module is the 902-920MHz ISM band transmitter used to transmit the audio signal to the headphone receiver device. This device is an integrated module that contains all of the circuitry needed to create the carrier and modulate the carrier from the base-band stereo audio signal. The 902-928MHz carrier is developed from a 14.4MHz TCXO oscillator on the board. This 14.4MHz oscillator is multiplied to the desired frequency using the LMX2332 PLL and VCO. The loop response of the VCO/PLL is set slow enough that the VCO can be modulated with an MPX type FM stereo signal. This MPX type stereo signal is created using a separate analog base-band processor section on the transmitter module board. This circuit limits the modulation signal if the input signal exceeds the recommended input signal range of the transmitter module. This circuit also provides the necessary 19KHz pilot tone required in the base-band MPX signal. The power supply within the transmitter module is regulated using a linear regulator. This allows the power supply to vary between 9V DC and 18V DC without affecting power or modulation.



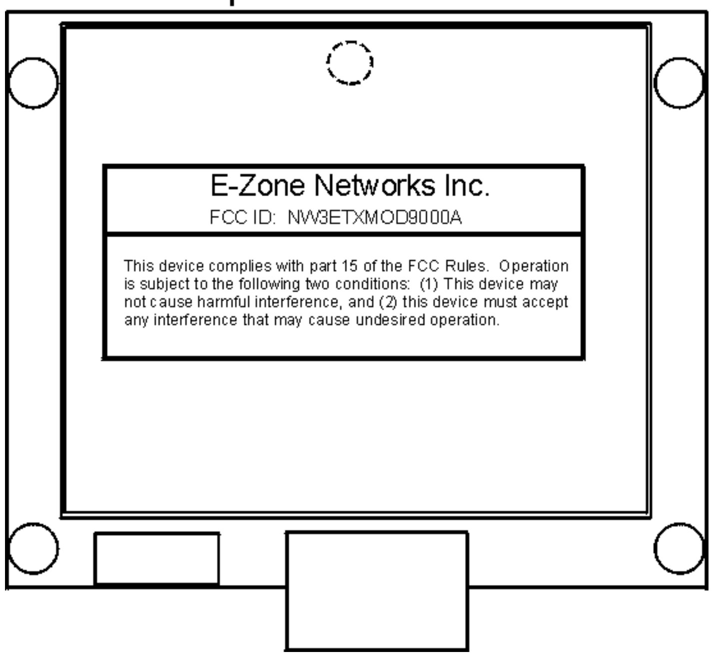
3.4.3 **TOP OF TRANSMITTER BOARD**

3.4.4 **BOTTOM OF TRANSMITTER BOARD**

3.5 Labeling Requirements – Per 2.1033(B)(7)

Label Placement:

Top View TX Module



The Label as shown above will be constructed as follows:

- **Material:**
  Label Stock Polyester, White Gloss, Permanent Adhesive
  Ribbon

- **Specifications:** Printing, base material and adhesive must be able to survive and maintain readability when used in an environment that will include higher than room ambient temperatures (to +40°C) and mild abrasion. Storage temperatures from –20°C to +80°C

The label will be placed on the top of the E-Zone TX module as shown in the picture above.

3.6 Typical Calibration procedure for Transmitter module.

3.6.1 TX software system overview

Contained within the transmitter module is a PIC microcontroller & EEPROM that is used to select frequencies, adjust output power, balance audio settings, and adjust modulation. This device provides an I2C serial interface to the main control board, several clocks for the MPX stereo baseband modulator, and signals that allow the RF section to be powered down when not needed. The EEPROM settings will be determined during calibration and automatically programmed at assembly time using a spectrum analyzer, or modulation analyzer like the HP8901B for calibration measurements and a PC type computer (to program the EEPROM through the I2C bus). These EEPROM settings will, from that point on, be loaded into the digital POT's during power-up of the transmitter.

In addition to setting up of the transmitter's calibration pots during power up there are several other dynamic functions that the transmitter will perform; these are:

- During operation of the transmitter, it is possible to send an I2C command to the transmitter module's PIC microcontroller to allow RF power output to be attenuated by specific amounts. The attenuation settings available are measured from the maximum and they are –2dB, -4dB, -6dB, -8dB, -10dB, and –16dB. These settings are relative to the maximum transmit RF power setting (described below). The purpose of this ability to allow several output power settings is so that the transmitter can be tailored to the environment. For example when several transmitting and receiving devices are physically close together but occupying separate channels, lowering the output power can reduce inter-modulation effects in the receivers.
- It is possible to send an I2C command to the transmitter module's PIC microcontroller to disable the 19KHz pilot tone that is normally included with the MPX baseband-modulating signal. The 19KHz pilot tone is only needed for stereo signal transmission. When there is no stereo signal available (typically TV audio is only mono), the 19KHz pilot tone would be turned off in the transmitter. The drop of the 19KHz pilot tone would be sensed in the headphone receiver circuitry. The result would enable mono only demodulation in the headphone. This has the effect to reduce background audio noise while in mono mode of the headphones by 6dB.
- It is possible to send an I2C command to the transmitter module's PIC microcontroller to power down the entire RF section. The purpose of this command would allow the tower unit to stop radiating a RF signal when there is no user listening to the tower.
- It is possible to send an I2C command to the transmitter module's PIC microcontroller to select the desired frequency of transmission of the tower. There are two possible ways that the frequency can be set on the transmitter module. 1) The transmitter module has PLL clock, data, and enable lines connected directly to the control board. This allows the control board to directly program the synth. IC. 2) The transmitter's PIC can also program the PLL clock, data and enable lines thus allowing the transmitter PIC to set the frequency of the transmitter (using an I2C command). The reason that there are two ways to set the transmitter frequency is that backwards compatibility is maintained
- When a set frequency command is sent through the I2C command bus to the transmitter module's PIC microcontroller, the transmitter has the ability to adjust calibration settings based dynamically on frequency. This is used to improve consistency and accuracy of frequency dependant components of the transmitter. These two main frequency dependant components are peak modulation, and output RF power. In an ideal transmitter these components are identical with respect to frequency, but in a real world transmitter this is not normally true. For example in a typical transmitter the output RF power can vary as much as 2-4dB across the frequency band. Also in an ideal transmitter the peak modulation with respect to modulation voltage is

identical for all frequencies. In a typical transmitter that uses direct VCO modulation such as the transmitter used in this E-Zones design, the modulation can vary as much as 20% across the 902 to 928MHz band. In order compensate for these variances across the frequency band, the PIC will make small attenuation adjustments to the output power to flatten the output power variances with respect to frequency (The typical improvements seen with these compensation abilities were +/- 2dB across the band before compensation, and +/- 0.3dB after compensation). The peak modulation variances are compensated similarly with respect to frequency (the typical modulation variances before compensation are +/-20%, and after compensation are +/-5%).

- When the frequency is set with the control board using the transmitter module's PLL clock, data and enable lines that are directly connected to the control board, the automatic compensation is disabled and a default calibration level is set for the RF power output and modulation settings which is common for any frequency. This feature allows backwards compatibility for older software that does not send I2C frequency set commands to the transmitter module's PIC microcontroller.

3.6.2 Output Power Calibration Procedure

3.6.2.1 Maximum allowable RF power output measurement determinations for calibration.

Actual radiated measurements were made at the Electronics Test Center (ETC) Open Area Test Site (OATS). (The ETC OATS site conforms to the requirements of ANSI C63.4 and CSA C108.8-M1938.) These measurements were recorded as follows:

Freq. (MHz)	Azimuth (deg)	Height (cm)	Polarity	SA Lvl (dBuV/m)	AF (dB)	CF (dB)	OF (dB)	Lvl (dBuV/m)	FCC Limit (dBuV/m)	P/F
902.200	255	113	Horz.	51.00	23.60	4.00	0.00	78.60	93.98	Pass
902.199	42	121	Vert.	61.20	22.81	4.00	0.00	88.01	93.98	Pass
915.000	85	113	Horz.	53.20	23.90	4.00	0.00	81.10	93.98	Pass
915.002	151	132	Vert.	65.70	22.87	4.00	0.00	92.57	93.98	Pass
927.801	88	113	Horz.	54.40	24.30	4.00	0.00	82.70	93.97	Pass
927.799	294	136	Vert.	64.00	23.01	4.00	0.00	91.01	93.97	Pass

* Data collected from submitted test report document.

After this data was collected, the 915.002MHz frequency was selected for measurement because it appears to be worst-case condition (closest to the FCC limit). The transmitting tower was set up to emulate the exact same calibration settings used for the FCC official test. The output power was measure at the antenna port of the transmitter at 915.002MHz frequency using an Anritsu MS2661B spectrum analyzer. The 93.41dBuV/m radiated measurement value translates into a measured value of -4.68dBm into 50ohms at the antenna port of the transmitter. Although –4.68dBm value should theoretically be below the 93.98dBuV/m radiated I felt that an actual maximum calibration level should be below this –4.68dBm level. This would allow for typical errors in accuracy of the measurement instruments, and method of measurement. I therefore chose a value of –6.68dBm to be my maximum RF power output that transmitter should be calibrated to at the antenna port. This should allow 2dB of headroom and still remain below the allowable FCC limit.

3.6.2.2 RF output power calibration procedure.

1) Set up the D-pot (Digital Pot) settings on the transmitter to approximate normal settings.

2) Set up the transmitter module to transmit a RF modulated signal (1KHz tone L+R and 19KHz pilot tone turned on).

3) Measure the RF antenna port output power at 6 frequencies (902,907,912,917,922,927) in the 902-928MHz ISM band.

4) At each band, adjust the power D-Pot so that the output power is –6.68dBm at each frequency. Store these values into a table within the EEPROM of the transmitter module. This table of D-Pot settings will be used to determine the power output D-pot settings when frequency compensation is enabled. Power output D-pot settings at frequencies that reside between calibrated table frequencies will be linearly interpolated between them.

5) Determine the lowest D-Pot setting of the 6 frequencies measured. Store this value into the EEPROM. This value will be the default D-Pot power setting when frequency compensation is disabled, or during power-up of the transmitter. (This D-Pot setting equates to the maximum RF output power frequency within the 902-928MHz band.)

6) All RF output power calibration settings have been measured and stored in EEPROM at this point.

7) Cycle the power on the transmitter (This should make the transmitter accept its new EEPROM default settings). Disable the frequency compensation. Measure the RF output power at the antenna port at 6 frequencies again. Enable the frequency compensation. Measure the RF output power at the antenna port at 6 frequencies again. Verify that all of the output power values measure –6.68dBm +/- 0.5dBm.

3.6.2.3 Peak modulation calibration procedure.

1) Set up the transmitter module to transmit a RF signal with only the 19KHz pilot tone modulation present.

2) Measure the peak modulation of the RF signal at 6 frequencies (902,907,912,917,922,927) in the 902-928MHz ISM band

3) At each band, adjust the MPX D-pot (modulation) so that the peak modulation of the modulated RF signal is 7.5KHz at each frequency. Store these values into a table within the EEPROM of the transmitter module. This table of D-Pot settings will be used to determine the MPX D-Pot settings when frequency compensation is enabled. MPX D-Pot settings that reside between calibrated table frequencies will be linearly interpolated between them.

4) Determine the average of the six D-Pot settings. Store this value into the EEPROM. This value will be the default D-Pot setting when the frequency compensation is disabled, or during power-up of the transmitter.

5) Set up the transmitter module to transmit a RF signal with the 19KHz pilot tone, and a 1KHz tone in both L and R inputs. The 1KHz tone inputs should be inverted between L and R inputs (180 degrees out of phase from each other). The 1KHz tone amplitudes should be set to 4Vp-p.

6) Set the frequency of the transmitter to 915MHz.

7) Adjust the L-R D-Pot setting so that the maximum deviation is 75KHz.

8) Store this value into the EEPROM. This value will be used as the default D-Pot setting for the L-R D-Pot.

9) All Modulation calibration settings have been measured and stored in EEPROM at this point.

10) Cycle the power on the transmitter (This should make the transmitter accept its new EEPROM default settings). Disable the frequency compensation. With no audio input into the transmitter, measure the peak deviation at each of the 6 frequencies within the 902-928MHz ISM band. Verify that they are 7.5KHz +/-0.6KHz at all 6 frequencies. Enable the frequency compensation. Again with no audio input into the transmitter, measure the peak deviation at each of the 6 frequencies within the 902-928MHz ISM band. Verify that they are 7.5 +/- 0.1KHz peak deviation at all 6 frequencies.